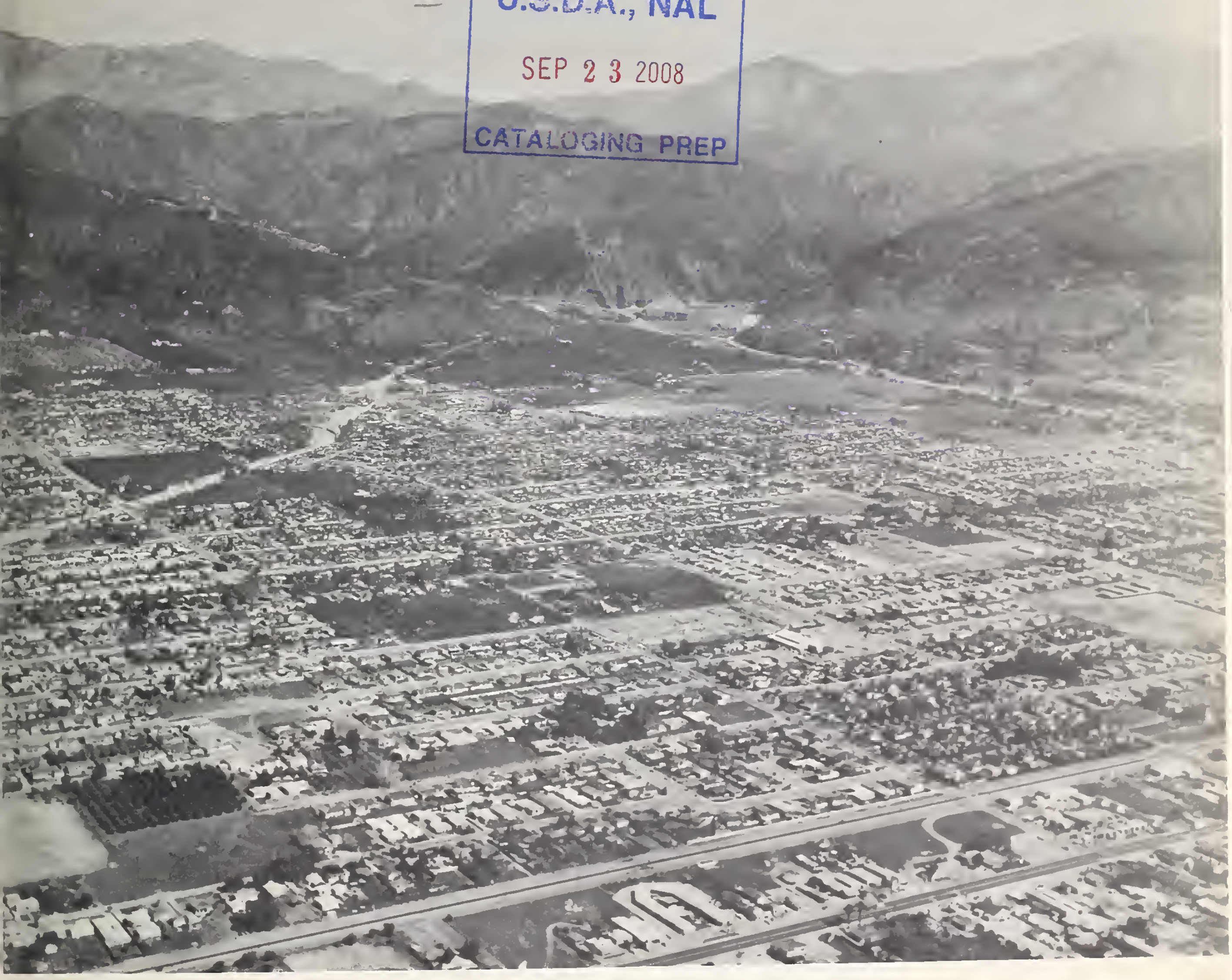
RESEARCH and a LAND MANAGEMENT MODEL for SOUTHERN CALIFORNIA WATERSHEDS



PACIFIC SOUTHWEST
FOREST AND RANGE
EXPERIMENT STATION
BERKELEY - CALIFORNIA

MISCELLANEOUS
PAPER . . . No. 56
MARCH - 1961

FOREST SERVICE - U. S. DEPARTMENT OF AGRICULTURE

Cover photo: The mountains and the city. The San Gabriel Mountains--some of the steepest most unstable mountains in the world--perched above a vast urban area. Research on the San Dimas Experimental Forest is aimed at controlling large brushland conflagrations, reducing floods and erosion, and improving water yield.

RESEARCH AND A LAND MANAGEMENT MODEL FOR SOUTHERN CALIFORNIA WATERSHEDS

By

2

Walt Hopkins, Jay Bentley, and Ray Rice

Contents — Page

Miscellaneous Paper 56

March 1961

U.S. Department of Agriculture, Forest Service
Pacific Southwest Forest and Range Experiment Station
Berkeley, California

The Johnstone Fire, about 30 minutes after the lightning strike, July 20, 1960. By nightfall the next day most of the 17,000-acre San Dimas Experimental Forest had been swept by the fire.

RESEARCH AND A LAND MANAGEMENT MODEL FOR SOUTHERN CALIFORNIA WATERSHEDS

By

Walt Hopkins, Jay Bentley, and Ray Rice

A noon-time bolt of lightning on a 107° day, July 20, 1960 is our starting point.

Within one hour fire had wiped out the vegetation on more than 400 acres--by nightfall 3,000 acres more. The end of the next day found more than 12,000 of the 17,000-acre San Dimas Experimental Forest with little remaining but exposed soil and ashes. By the end of the week about 15,000 acres were burned over. None of the experimental watersheds was spared.

In one sense, the fire was a major scientific disaster. Research installations and chaparral vegetation under study since 1932 were gone. But the fire did not make San Dimas a total loss to science. The fire had created a large area of chaparral land in critically unstable condition--a condition that occurs all too often in southern California. Here for the first time, however, fire had swept an area where soils, vegetation, and watersheds have been studied intensively for more than a quarter-century. Thanks to prompt action and a great deal of help, we have been able to turn the situation to advantage.

Before the fire was under control, improvised stream-gaging stations and raingages were "jury rigged" and back in operation, and emergency research planning was started. Plans were drawn to re-establish field installations and to evaluate broadscale land treatment measures aimed at stabilizing and managing fire-denuded watersheds. This is a unique opportunity to capitalize on past knowledge. For the first time we are able to measure quantitatively the results of restoration, protection, and management efforts on chaparral land.

Through the combined efforts of several agencies, the job of establishment is nearly finished. The San Dimas Experimental Forest is rapidly becoming the most intensively studied and managed block of wildland in the country. Congress provided a supplemental appropriation. The engineering staff of the Angeles National Forest has handled much of the rehabilitation planning and supervision. Labor crews provided by the California Division of Forestry and the Los Angeles County Fire Department have been working side by side with Forest Service crews for months. The State Department of Water Resources and the Los Angeles County Flood Control District have provided engineering

survey teams and engineering planning and design for streamflow- and sediment-measuring structures. As a consequence, the San Dimas Experimental Forest is well embarked on a 5-pronged research program:

1. Emergency sowing of burned-over watersheds
2. Erosion control
3. Conflagration control
4. Improvement of water yield
5. Development of a large pilot model for the management of chaparral lands.

EMERGENCY SOWING OF BURNED-OVER WATERSHEDS

Emergency sowing of herbaceous plants soon after a fire is an accepted practice in southern California watersheds. The purpose of this first aid treatment is to establish a temporary cover for protection of the watershed while the brush is slowly recovering.

Although reasons for sowing denuded watersheds are obvious, the effects of sowing have never been quantitatively measured. Does the added cover pay in terms of reduced sediment in the stream channels? Are more expensive and more effective revegetation measures justified? The burned watersheds of the experimental forest should answer these questions.

Annual species are usually sown because annuals are hardy and reseed themselves each year. The seed is abundant and cheap. For years black mustard was the most commonly sown species. In the last 6 years it has been largely replaced by common ryegrass in southern California, but on San Gabriel watersheds the two species have been sown in mixtures. Two other annuals--Wimmera ryegrass and Blando brome--are now being used in some sowings. Which of the annuals provides the best cover on different sites? This is another question being studied.

Deep-rooted perennial grasses also have been suggested for emergency temporary cover. They are commonly sown where permanent cover is desired, but perennials have never been widely tested on burned-over southern California watersheds. They are now being compared with annuals in the experimental watersheds to see if they provide better cover, especially at upper elevations too cold for good growth of annuals. The comparisons include tests of individual species and mixtures of species as both emergency and permanent cover.

From October 23 to November 29, a total of 13,496 acres were sown by helicopter within and adjacent to the experimental forest. An additional 83 acres were sown by hand, and 29 acres were sown with a heavy duty rangeland drill.

"First aid" in action--loading a helicopter for emergency watershed revegetation. Except for control areas designated for no artificial seeding, the entire experimental forest was sown to selected annual or perennial grasses in the fall of 1960.

Helicopter costs for sowing large areas with 10 pounds of seed per acre, were about $1.00 per acre. For small watersheds and plots, the cost of aerial application was about doubled. Seed cost about 60 cents an acre for common ryegrass and mustard, and $2.00 to $7.00 for the perennial grass mixtures.

EROSION CONTROL

Southern Californians know all too well the consequences when heavy rainstorms hit fire-denuded watersheds. The San Dimas Experimental Forest has furnished some of the evidence. For example, in 1953 the upper 500 acres of 1,500-acre Wolfskill Canyon were burned. The first storm after the fire was not too uncommon--the kind you can expect every 3 or 4 years. It produced a flood peak 68 times the normal, and erosion was increased 30 times.

Another example has been recorded in Bell Watershed No. 2 since the 1960 fire. Over the past 27 years annual erosion rates have averaged about 1,800 cubic yards per square mile.

Building contour terraces. In addition to revegetation, physical measures aimed at retarding runoff and erosion are being tested in experimental watersheds.

The first storm after this fire, on October 9, 1960, wasn't much of a storm--0.94 inch in 19 hours. Yet the erosion rate was more than 3,000 cubic yards: 1.7 times the annual rate from just one small storm.

In fact, it doesn't have to rain for erosion to be a problem. A study in the Arroyo Seco, a few miles west of the experimental forest, revealed that (1) dry creep erosion in the steep unstable San Gabriel Mountains can exceed water-borne erosion, and (2) post-fire dry season erosion was 2 to 35 times the preburn rate.

Now we are embarked on intensive tests comparing nearly 30 alternatives aimed at reducing post-fire soil erosion. If erosion rates could be reduced even a small amount, the savings would be sizable.

Small Watershed Tests

Twenty-five small watersheds varying in size from 2 to 8 acres have been established near the Tanbark field headquarters. Each has a flow measurement flume and debris basin, and except for an untreated control watershed to be used as a basis for comparison, each has one of, or combinations of, the following physical or vegetative treatments:

1. Contour basin-terraces.--Large permanent terraces were constructed in 9 of the watersheds. This practice was developed in the Intermountain Region of the Forest Service. The terraces were constructed with a heavy bulldozer and were spaced on contour 40 to 90 feet apart depending on slope. A completed terracing system provides dead storage for a storm that produces about 3 inches of rain. The system will also store about 550 cubic yards of sediment per acre.

Completed terrace. The listed basins hold runoff and lessen the lateral movement of water within the terrace.

Side slope stabilization. Barley planted in furrows on close contours.

2. Side slope stabilization.--To impede overland flow of water and sediment on side slopes in 9 of the small experimental watersheds, barley seed and fertilizer were placed in furrows to form dense rows on 2-foot contour intervals. Barley was chosen because it grows more vigorously than most species during cool winter weather. The fertilizer was included to promote earlier and heavier growth.

3. Stream channel checks.--Small dams were constructed of cement combined with soil and rock available at the dam sites in 9 of the watersheds. Purpose of these dams is to prevent channel downcutting, to stabilize side slope soils, and to spread out streamflow, thereby reducing its velocity and erosive power.

4. Broadcast sowing of perennial grasses.--A mixture of perennial grasses with a small amount of annuals was sown at a rate of 20 pounds per acre in 4 watersheds, and at 4-1/4 pounds in 4 others. Hardinggrass and pubescent wheatgrass were the dominant deep-rooted perennials.

5. Broadcast sowing of annual grasses.--Nine other watersheds were sown with annual grasses--5 at 20 pounds per acre and 4 at 2-1/2 pounds. The mixture was composed of 4 parts Wimmera ryegrass and 1 part Blando brome.

Constructing channel checks. Soil cement channel checks to reduce downcutting, stabilize side slopes, and spread streamflow are under test in nine experimental watersheds.

Constructing watershed flume to measure storm flows and suspended sediment. Note debris basin and spillway downstream and in background.

The use of soil binder chemicals was also explored. We had hoped to find a chemical to stabilize the soil during the early part of the rainy season before an effective plant cover can be established. Twelve chemicals were studied in the laboratory, and three of these were tested in large field plots under artificial rainfall. The trials did not uncover a chemical sufficiently promising for application in the small watersheds. Despite this disappointment, it is recognized that erosion control during the critical period immediately after a fire is a serious problem, and ways must be found to protect the soil prior to vegetation establishment. Further chemical tests will be made.

Mustard-Ryegrass Watersheds

Eleven other watersheds varying in size from 9 to 87 acres, each with a flume to measure flows and suspended sediment, are dedicated to a comparison of ryegrass vs. mustard as an emergency vegetative cover. This is the first time it has been possible to make a quantitative comparison of these alternatives.

Lysimeter Tests

The burned-over lysimeters are again at work. The new study seeks to answer the question "How do infiltration rates vary under a mustard or ryegrass cover?" If one plant encourages more infiltration and percolation than the other, runoff would be less, and presumably erosion rates would also be less.

CONFLAGRATION CONTROL

An obvious first step in reducing erosion and flood damage is to prevent widescale destruction of the vegetation by disastrous fires. For this reason, fire control effort in southern California brushfields is more intensive than on any other kind of wildland. Firefighting forces are highly organized and equipped for fast, hard hitting ground and aerial attack. Aggressive action controls some 98 percent of the fires while still small. Yet, despite many recent improvements in firefighting, large acreages are burned each year.

The few fires which escape early control, usually under extreme weather conditions, build up into conflagrations. Where terrain is so excessively steep and the heavy fuels are tinder dry, such fires cannot be readily stopped in the continuous cover of dense brush. By the time expensive, back-breaking effort, aided by favorable weather, has confined the fire, thousands of acres have burned.

A new approach that is rapidly gaining momentum, is to modify the fuel conditions by breaking the expanses of brush into smaller units for more effective fire control. This is done

by converting the heavy brush to a cover of light-volume fuel, such as grass, at strategic intervals on wide strips or blocks of land. These are called fuel-breaks. The breaks provide access for safer firefighting where modern techniques can be more effective.

Firefighting agencies in southern California started several years ago by building wide breaks instead of the old narrow ones. In 1957, they organized a research and action program aimed at improving the techniques for building breaks and at expanding use of this new approach to fire control. Numerous fuel-break demonstrations have been started and more are planned.

Now, the experimental forest provides an area where an intensive fuel-break system can be developed as a model of the future for San Gabriel watersheds. This system has been planned, and chemical control of brush regrowth will start this year on 2,000 acres. About 1,000 more will be added within the next two years.

Studies to sharpen the techniques of brush conversion on this kind of land have also been started. The sites have been classified and mapped. Adaptation of different plant species as permanent cover is being tested, and methods for their establishment on different sites are being developed. Included are plants which have been reported to be fire retardant or slow burning. Techniques of aerial spraying and hand spraying to eliminate brush will be tested extensively.

IMPROVEMENT OF WATER YIELD

Research at San Dimas aimed at the improvement of water yield starts with the fundamental question upon which the experimental forest was founded--what happens to rainfall when it reaches the watershed? Over the years it was found that during an average year of 27 inches of rainfall, evapotranspiration losses were 15 inches--indicating considerable opportunity for water savings. The lysimeters and then plot studies showed that only under a grass cover, and then only on deep soils, was there opportunity for increased groundwater yield.

Drawing on these results, in 1958 we placed two watersheds under intensive management. In Monroe Canyon we started to see how much more water can be yielded by removal of riparian and associated streambottom vegetation. In Bell Watershed No. 2, we asked "How much more water can be yielded by deadening side-slope chaparral growing on deep soils?" Two valuable years of records were obtained before the fire.

Monroe Canyon Study

The performance of Monroe Canyon and that of adjoining Volfe Canyon, each with a long-established chaparral cover, had been measured for more than 20 years. In the spring of 1958 and in the spring of 1959, a total of 38 acres of riparian and associated streambottom trees were removed from Monroe Canyon. This was followed by herbicide spraying of brush and stump sprouts.

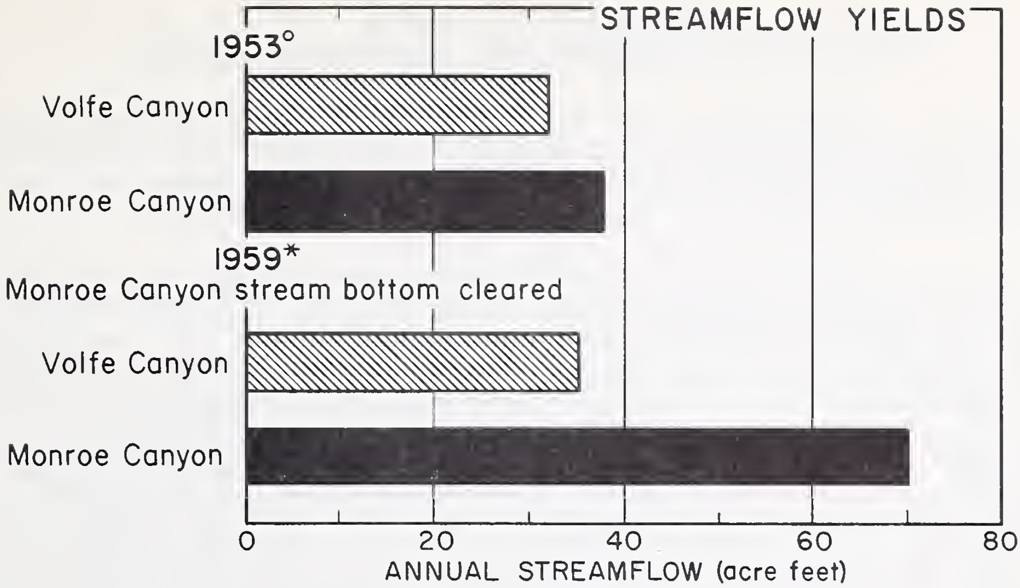
Both 1958-59 and 1959-60 were "dry": rainfall was about half the average. Despite this, during the 12-month period, June 1, 1958 through May 31, 1959, streamflow in Monroe Canyon was 30 acre-feet more than would have been expected if the streambottom had not been cleared--about an acre-foot of water for each cleared acre.

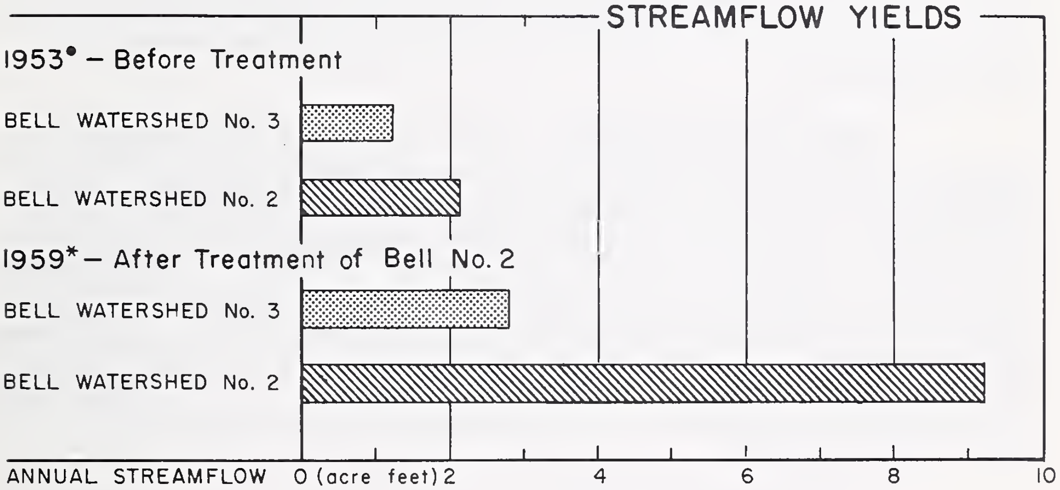
This major study aimed at management for increased water yield continues as part of the post-fire research program. A soil survey was made. The deep soils in Monroe Canyon are located. The canyon has been seeded with a mixture of Wimmera ryegrass and Blando brome. The deep soil areas and the canyon bottom will be sprayed with a herbicide as often as necessary to maintain a grass cover. Volfe Canyon, on the other hand, was not and will not be seeded. It will continue as an unmanaged control for comparison with Monroe Canyon.

Bell Watershed Number 2

Forty acres of chaparral in 100-acre Bell Watershed No. 2 were sprayed with a mixture of 2, 4-D and 2, 4, 5-T in the spring of 1958, then again in 1959 and 1960. Adjoining Bell No. 3 was left unsprayed as a control. When comparable periods of current and antecedent rainfall are compared, we find that streamflow in treated Bell Watershed No. 2 was about 5 1/2 acre-feet greater than would have been expected without treatment; this amounts to an annual increase of about 1/10 of an acre-foot per acre treated.

In the post-fire research program, management of Bell Watershed No. 2 is similar to that of Monroe Canyon. The watershed has been seeded to Wimmera ryegrass and Blando brome. Vegetation on deep soils and in the riparian zone will be sprayed with herbicides as often as necessary. Meanwhile, its performance will be compared with that of (a) Bell Watershed No. 3, which has been seeded to domestic ryegrass; (b) Bell Watershed No. 4, which has not been seeded at all; (c) Bell No. 1, which has been seeded to perennial grasses.





• June 1, 1952 through May 31, 1953 (Rainfall: Current year 15.9 inches, antecedent year 40.5 inches)

*June 1, 1958 through May 31, 1959 (Rainfall: Current year 14.9 inches, antecedent year 47.3 inches

(Above) Effect of removing canyon bottom trees and brush. Streamflow from managed Monroe Canyon and unmanaged Volfe Canyon for comparable periods before and after 38 acres of stream channel vegetation was removed from Monroe Canyon.

(Below) Streamflow from managed Bell Watershed No. 2 and unmanaged No. 3 for comparable periods before and after 40 acres of brush were deadened by herbicides on side slopes with deep soils in 100-acre No. 2.

PILOT PLANT MODEL
FOR THE MANAGEMENT OF CHAPARRAL LANDS

In addition to its use as the primary chaparral research field laboratory for studies of plant-soil-water relations, the entire 17,000-acre San Dimas Experimental Forest will become a pilot model for intensive chaparral management.

Except where overall management is in direct conflict with individual research studies, management objectives will aim at conflagration control, flood and erosion control, the maximum production of high quality water, and the development of suitable recreation sites. A comprehensive plan will be prepared for the long-time management of the forest. It will be modified over the years as research shows new practices which should be applied. The plan will include a model fuel-break system to divide the expanse of dense brush into smaller units as it regrows. The system will include other elements of an intensive pre-attack fire control plan, such as access roads, trails, tractor-ways, helispots, water tanks, pump and hose installations, and the necessary fire control crews. Side-slope and stream-channel erosion control measures will be applied and coordinated with other management objectives.

Specified watersheds, such as Volfe Canyon which is the control watershed used for comparison with managed Monroe Canyon, will not be placed under pilot plant management. Other watersheds, however, in which applied management will not interfere with, or may even augment research studies, will be pilot managed. Riparian and associated woodland vegetation and chaparral growing on side slopes with deep soils will be deadened. Fuel-breaks will be established, maintained, and improved. Channel stabilization structures will be installed. If terraces and other physical measures now under study prove successful, they too will be included.

A prescription will be written for each watershed. Then--within the scope of available manpower, equipment, and materials--erosion control measures and steps to improve water yield will be applied. The most critical areas, or those with the most promise of improvement will be tackled first, and in due course, improving as we go, the entire tract will be under intensive management--a multiple use model to guide the management of some of the most important wildland watersheds in the country.